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## (54) Engine throttle control system.

(57) An engine throttle control system controls a throttle motor (6) connected to a throttle butterfly (5) of an engine (1) which drives a vehicle via a multi-ratio transmission (2, 3). The maximum rate of change of throttle position signals ($\theta d$) is limited by a slew limiter (10) to a low limit (15) when the transmission (2, 3) is engaged and to a high limit (14) when the transmission (2, 3) is disengaged. In the absence of normal driver-produced movements of an accelerator pedal, the throttle opening is reduced and restored only if a prompt driver response is detected, such as increased depression of the accelerator pedal.

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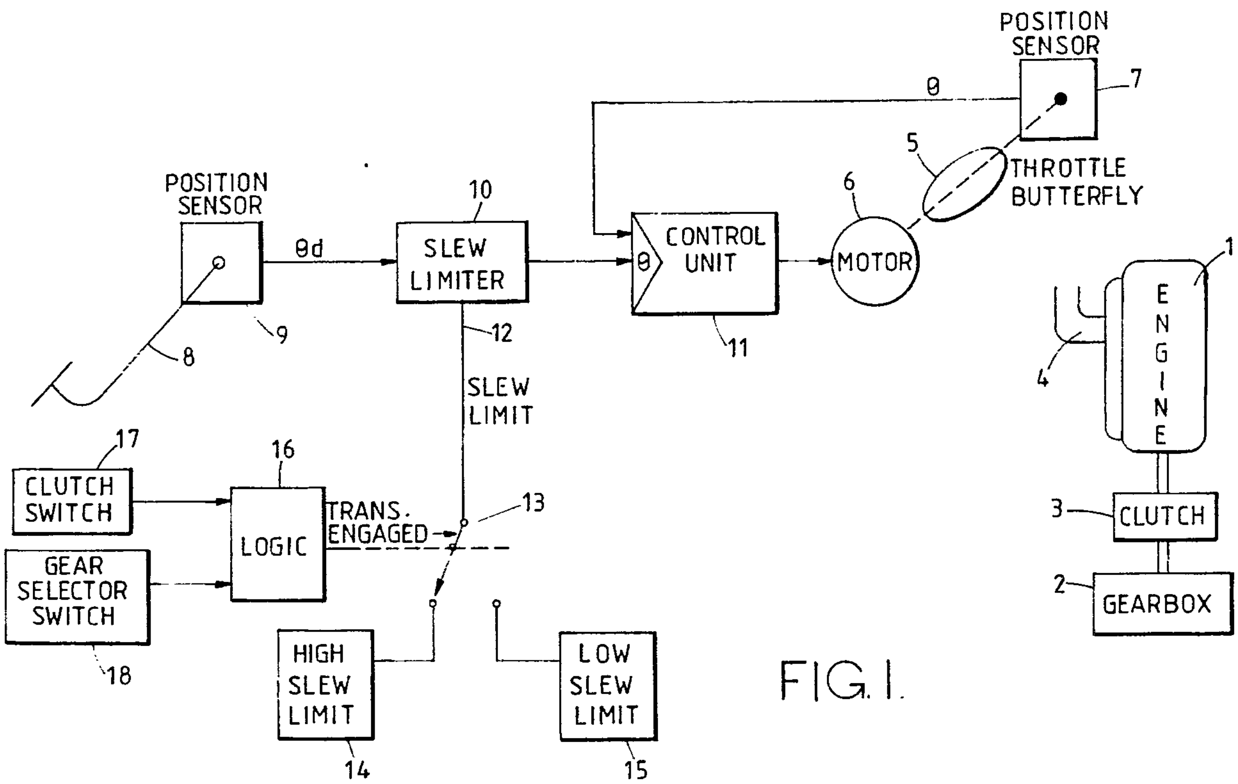

POSITION SENSOR
7
θ
5
THROTTLE BUTTERFLY
6
POSITION SENSOR
10
θd
SLEW LIMITER
θ
CONTROL UNIT
MOTOR
1
ENGINE
9
8
12
11
4
SLEW LIMIT
17
16
CLUTCH SWITCH
LOGIC
TRANS. ENGAGED
13
3
CLUTCH
GEAR SELECTOR SWITCH
2
GEARBOX
18
HIGH SLEW LIMIT
LOW SLEW LIMIT
14
15

FIG.1.

# ENGINE THROTTLE CONTROL SYSTEM

The present invention relates to an engine throttle control system, for instance for use in controlling an internal combustion engine for driving a vehicle.

Throttle control systems for controlling petrol and diesel engines for vehicles include the so-called "drive by wire" system in which there is no mechanical linkage between a driver actuated accelerator pedal or cruise control command switch and a mixture controlling system, such as one or more carburettors or a fuel injection system. Systems of this type also lend themselves readily to automatic traction control functions for preventing wheel spin during heavy acceleration and/or in conditions of poor ground adhesion. However, special requirements are placed on the performance and safety of such systems, which must function reliably and in accordance with various design parameters at all times.

In such control systems, the drivability of the vehicle can be improved by slowing down the movement of the throttle relative to the movement of the accelerator pedal. However, this can cause problems during gear changes where it is desirable for the throttle to respond rapidly to changes in position of the accelerator pedal.

A potentially dangerous situation arises where a driver becomes sleepy, for instance during a long journey along monotonous roads. Drive by wire throttle control systems allow action to be taken in order to slow down or stop a vehicle provided it is possible to detect when a driver is becoming drowsy or is beginning to fall asleep. However, it is difficult to detect such a condition in a driver, although attempts have been made in the past by relying on systems which are additional to the normal control systems of a vehicle.

According to a first aspect of the invention, there is provided an engine throttle control system for controlling a throttle of an engine of a vehicle having a multi-ratio transmission, comprising a control circuit for controlling the throttle in response to a demand signal, the control circuit including a slew-rate limiting circuit arranged to limit the slew-rate of the demand signal to a first rate limit when the transmission is in a torque transmitting mode and to a second rate limit higher than the first rate limit when the transmission is in a torque non-transmitting mode.

This may be achieved, for instance, by effectively disabling the slew-rate limiting circuit when the transmission is disengaged, so that the second rate limit is determined by other factors or is not defined, but may well be higher than the maximum possible slew-rate of the demand signal.

In the case of a manual transmission comprising a clutch and a gear box, sensors may be arranged to detect when a clutch pedal is depressed or a gear selector is in neutral so as to control selection of the second rate limit.

Thus, a desirable rapid throttle response can be achieved during gear changes while the slower response during driving provides improvements to the drivability of a vehicle.

According to a second aspect of the invention, there is provided an engine throttle control system for a vehicle, comprising a control circuit for supplying a throttle position control signal in response to a throttle position demand signal from an accelerator pedal, the control circuit comprising means for reducing the throttle position control signal relative to the throttle position demand signal in response to a relatively slow rate of change of the throttle position demand signal.

Preferably the throttle demand is reduced only if the vehicle speed exceeds a predetermined speed.

Preferably the rate of reduction of the throttle position control signal increases in the absence of an increase in the throttle position demand signal.

Preferably the throttle position control signal is increased to an unreduced value in response to an increase in the throttle position demand signal. Preferably the throttle position control signal increase takes place only when the throttle position demand signal is unchanging or increasing.

It is thus possible to detect when a driver is drowsy or tending to fall asleep and to reduce the speed of a vehicle until the driver responds by further depressing the actuator. By reducing the speed, the severity of an accident can be reduced. A warning device, for instance for sounding an audible alarm for rousing or waking up the driver, may be actuated if the driver does not take remedial action, for instance within a predetermined time of beginning to reduce the demand signal.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a block schematic diagram of an engine throttle control system constituting a first embodiment of the invention;

Figure 2 is a block schematic diagram illustrating hardware of a microcomputer based second embodiment of the invention; and

Figure 3 is a flow chart illustrating software for controlling operation of the hardware shown in Figure 2.

Figure 1 shows a throttle control system for an engine 1 driving a vehicle through a multi-ratio transmission, shown by way of example as a manual gearbox 2 associated with a clutch 3. The engine 1 has an inlet manifold 4 in which is located a throttle butterfly 5 actuated by a motor 6 and connected to a position sensor 7.

An accelerator pedal 8 is provided with a position sensor 9 which provides a throttle demand signal $\theta_d$ to a slew limiter circuit 10. The output of the slew limiter circuit 10 is supplied as a demand signal to a first input of a control unit 11 whose output drives the motor 6. The motor controls the position of the engine throttle 5 and the position transducer 7 supplies a throttle position signal $\theta$ to a second input of the control unit 11.

The slew limiter circuit 10 has a controllable slew rate limit controlled by an input 12 connected to a switch 13. The switch 13 is arrange to select between a high slew limit 14 and a low slew limit 15. A selection control input of the switch 13 is connected to the output of a logic circuit 16 which has inputs connected to a clutch switch 17 for detecting when the clutch 3 is disengaged and a gear selector switch 18 for detecting when a gear selector of the gearbox 2 is in the neutral position

Whenever the clutch is engaged and a gear or transmission ratio is selected, the logic circuit 16 supplies an output signal which causes the switch 13 to select the low slew limit 15. The slew limiter circuit 10 thus limits the maximum slew rate of the throttle demand signal $\theta_d$. The rate at which the throttle 5 can move to a new demanded position is therefore limited, thus improving the drivability of the vehicle.

Whenever the clutch is disengaged or the gear selector is at a neutral position ie., no gear is selected, the logic circuit 16 causes the switch 13 to select the high slew limit 14. The throttle 5 can therefore respond more quickly to changes in throttle demand, providing a more desirable engine response in these circumstances.

The engine throttle control system shown in Figure 2 comprises a throttle 20 driven by a motor 21 and provided with a return spring 22. The throttle 20 is connected to a throttle angular position transducer 23 whose output provides a signal $\theta$ representing the throttle opening angle to the input of one of a set of analog/digital converters 24. Another of the converters 24 receives a throttle position demand signal $\theta d$ from a position sensor 25 which senses the position of an accelerator pedal 26. Others of the converters 24 receive further signals, for instance from various sensors associated with the engine.

The converters 24 are connected to a bus 27 which is connected to a micro-computer 28 including a micro-processor, a program memory 29 in the form of a read-only memory, a volatile read/write (random access) memory 30, and a non-volatile read/write memory 31. The bus 27 carries addresses, data, and control signals for all of the devices connected thereto. The program or software for controlling the micro-computer 28 is stored in the memory 29. The memory 30 acts as a working or "scratch pad" memory for storing data used during operation of the system but not requiring permanent storage. The memory 31 provides storage of, for instance, operating parameters and updating of such parameters, which are required during future operation of the system irrespective of whether the system is switched off or the power supply disconnected in the interim. The micro-computer 28 has outputs 32 for controlling other internal combustion engine systems, such as ignition timing and various aspects of fuel supply to the engine.

A digital/analog converter 33 is connected to the bus 27 and has an analog output connected to a half-wave rectifier 34 for passing only positive signals and to a half-wave rectifier 35 for passing only negative signals. The outputs of the rectifiers 34 and 35 are connected to the inputs of motor drive amplifiers 36 and 37, respectively, whose outputs are connected to the motor 21.

The hardware of the system shown in Figure 2 is under software control and acts as an engine management system for controlling operation of the engine. Data from various sensors, including the position sensors 23 and 25, are supplied to the micro-computer via the converters 24 and, on the basis of the received data, the micro-computer supplies output signals for controlling the engine at the outputs 32 and via the converter 33. The output signals of the converter 33 are split by the rectifiers 34 and 35 into positive and negative signals and drive the motor 21 via the amplifiers 36 and 37 in respective directions.

Figure 3 is a flow chart illustrating in more detail the operation of part of the control system shown in Figure 2. Normal operation of the engine throttle control system is illustrated by block 40. At 41, the micro-computer determines the rate of accelerator pedal movement and, at 42, forms and updates a moving average of this rate. At 43, the micro-computer determines whether the average rate of movement is low, for instance less than a predetermined threshold. If not, the micro-computer returns to normal operation 40. If the average rate is low, the micro-computer determines at 44 whether the road speed of the vehicle is high, for instance above a predetermined speed. If not, then normal operation 40 is resumed. If the road speed is high, the micro-computer decrements, at 45, the gain applied to a throttle demand signal, so that the demand signal is reduced. The micro-computer then checks at 46 whether there is a prompt response by the driver. If not, then the size of the decrement is increased at 47 and the step 45 is performed again.

When the micro-computer detects a prompt response by the driver, for instance pressing down harder on the accelerator pedal, the micro-computer restores the original gain gradually, except when the pedal is being operated to decrease the throttle demand, at 48 and returns to normal operation 40.

The system therefore periodically tests the responses of a driver in such a way that, if a driver is awake and alert, no action is taken. However, if a driver becomes drowsy or falls asleep, the foot pressure on the accelerator pedal is such that the pedal stops moving or, under the action of a return spring, begins to rise as the foot pressure is slowly released. If the road speed is relatively low, then no action is taken. However, if the road speed is relatively high, the system responds by reducing the pedal-to-throttle gain in a sequence of increasing steps. If the driver is awake and alert, the normal reaction is to press harder on the accelerator in order to compensate for any loss of power or speed of the vehicle. Such compensation is performed automatically by the driver and, under these circumstances, normal operation is resumed by gradually restoring the original gain.

If the driver fails to respond, this is taken as an indication that he is not alert and may be drowsy or even asleep. The effect of progressively reducing the gain by increasing step sizes is to reduce the speed of the vehicle until it is relatively low so as to reduce the danger should an accident occur. Preferably, a warning such as an audible alarm is provided in order to wake up the driver or make the driver more alert.

## Claims

1. An engine throttle control system for controlling a throttle of an engine of a vehicle having a multi-ratio transmission, comprising a control circuit for controlling the throttle in response to a demand signal, characterised in that the control circuit (10-18) includes a slew-rate limiting circuit (10, 12-18) arranged to limit the slew-rate of the demand signal to a first rate limit when the transmission (2,3) is in a torque transmitting mode and to a second rate limit higher than the first rate limit when the transmission is in a torque non-transmitting mode.

2. A system as claimed in Claim 1, characterised in that the slew-rate limiting circuit is arranged to be disabled when the transmission is in the torque non-transmitting mode.

3. A system as claimed in Claim 1 or 2 for a vehicle having a manual gearbox, characterised by a gearbox sensor (18) arranged to sense when a gear selector of the gearbox (2) is in neutral.

4. A system as claimed in any one of the preceding Claims for a vehicle with a pedal-actuated clutch, characterised by a clutch sensor (17) arranged to sense when the clutch pedal is depressed.

5. A throttle control system for a vehicle, comprising a control circuit for supplying a throttle position control signal in response to a throttle position demand signal from an accelerator pedal, characterised in that the control circuit comprises means for reducing the throttle position control signal relative to the throttle position demand signal in response to a relatively slow rate of change of the throttle position demand signal.

6. A system as claimed in Claim 5, characterised in that the reducing means is enabled only when vehicle speed exceeds a predetermined speed.

7. A system as claimed in Claim 5 or 6, characterised in that the reducing means is arranged to increase the rate of reduction of the throttle position control signal in the absence of an increase in the throttle position demand signal.

8. A system as claimed in any one of Claims 5 to 7, characterised in that the reducing means is arranged to restore the throttle position control signal to an unreduced value in response to an increase in the throttle position demand signal.

9. A system as claimed in Claim 8, characterised in that the reducing means is arranged to restore the throttle position control signal only when the throttle position demand signal is unchanging or increasing.

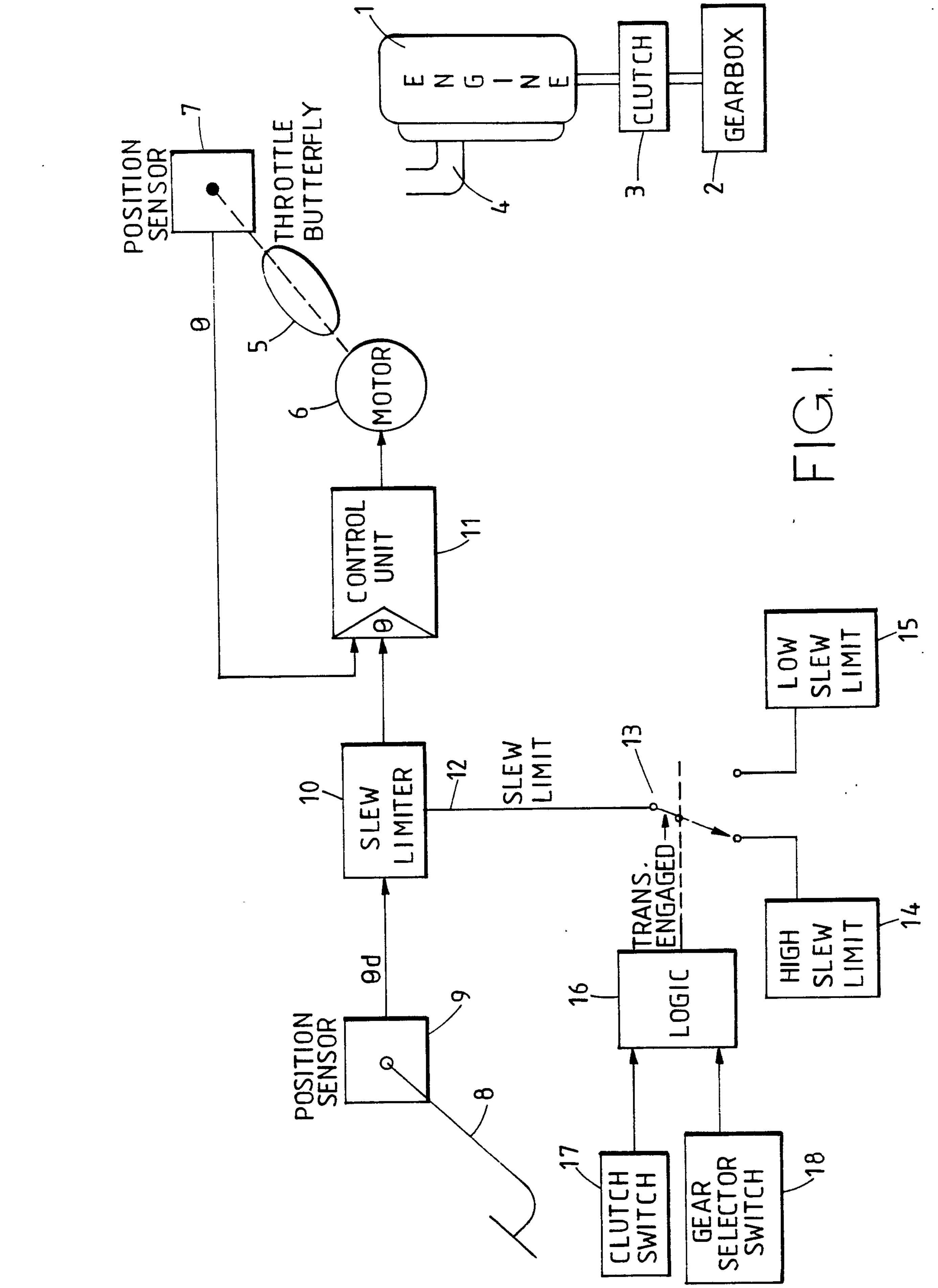
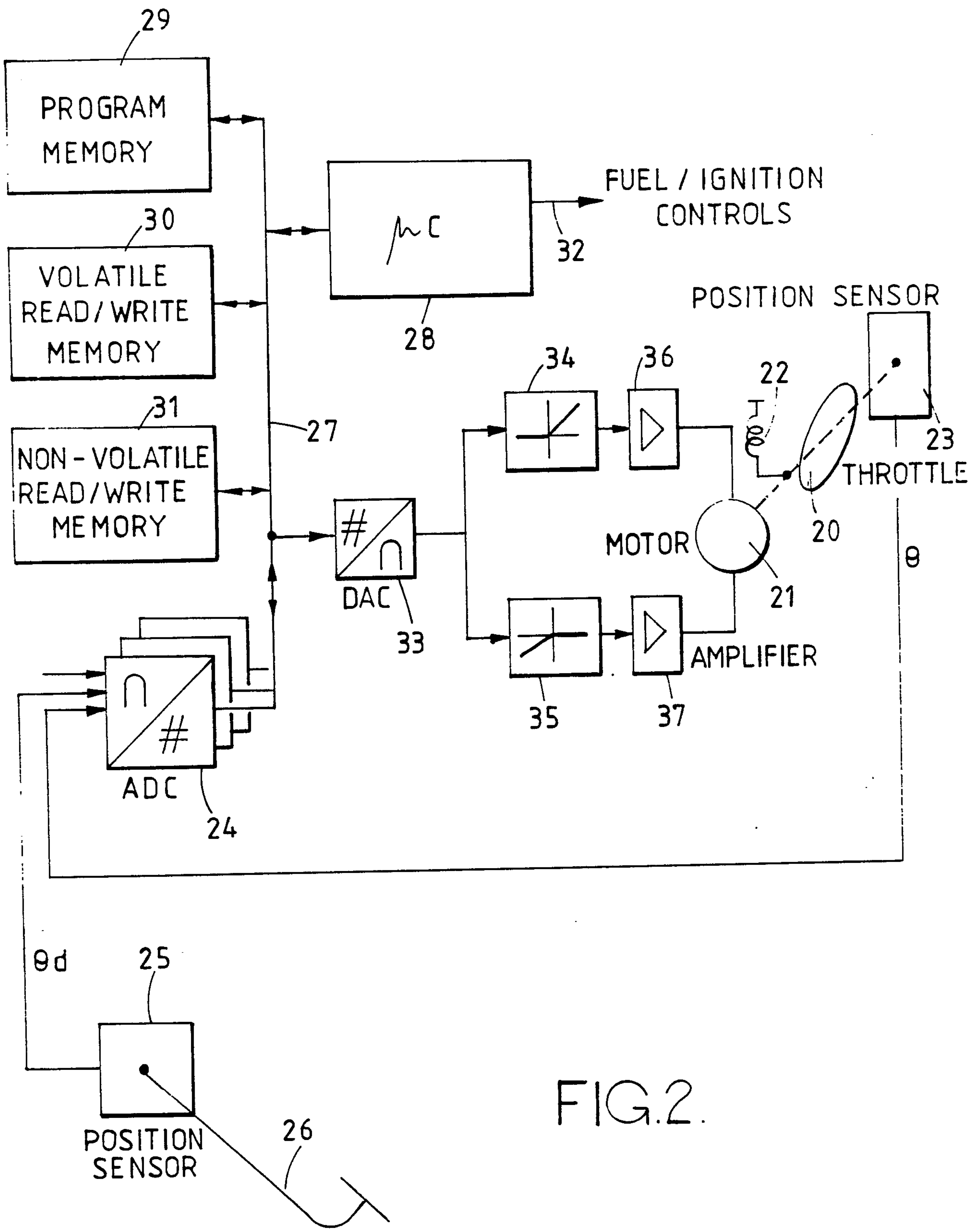

POSITION SENSOR
7
THROTTLE BUTTERFLY
1
ENGINE
CLUTCH
GEARBOX
3
2
4
θ
5
MOTOR
6
CONTROL UNIT
11
θ
POSITION SENSOR
9
θd
SLEW LIMITER
10
12
SLEW LIMIT
13
TRANS. ENGAGED
LOW SLEW LIMIT
15
HIGH SLEW LIMIT
14
LOGIC
16
8
CLUTCH SWITCH
17
GEAR SELECTOR SWITCH
18

FIG. 1.



29
PROGRAM MEMORY
30
VOLATILE READ/WRITE MEMORY
31
NON-VOLATILE READ/WRITE MEMORY
27
μC
28
FUEL / IGNITION CONTROLS
32
POSITION SENSOR
34
36
22
23
THROTTLE
20
MOTOR
21
θ
DAC
33
AMPLIFIER
35
37
ADC
24
θd
25
POSITION SENSOR
26


FIG.2.

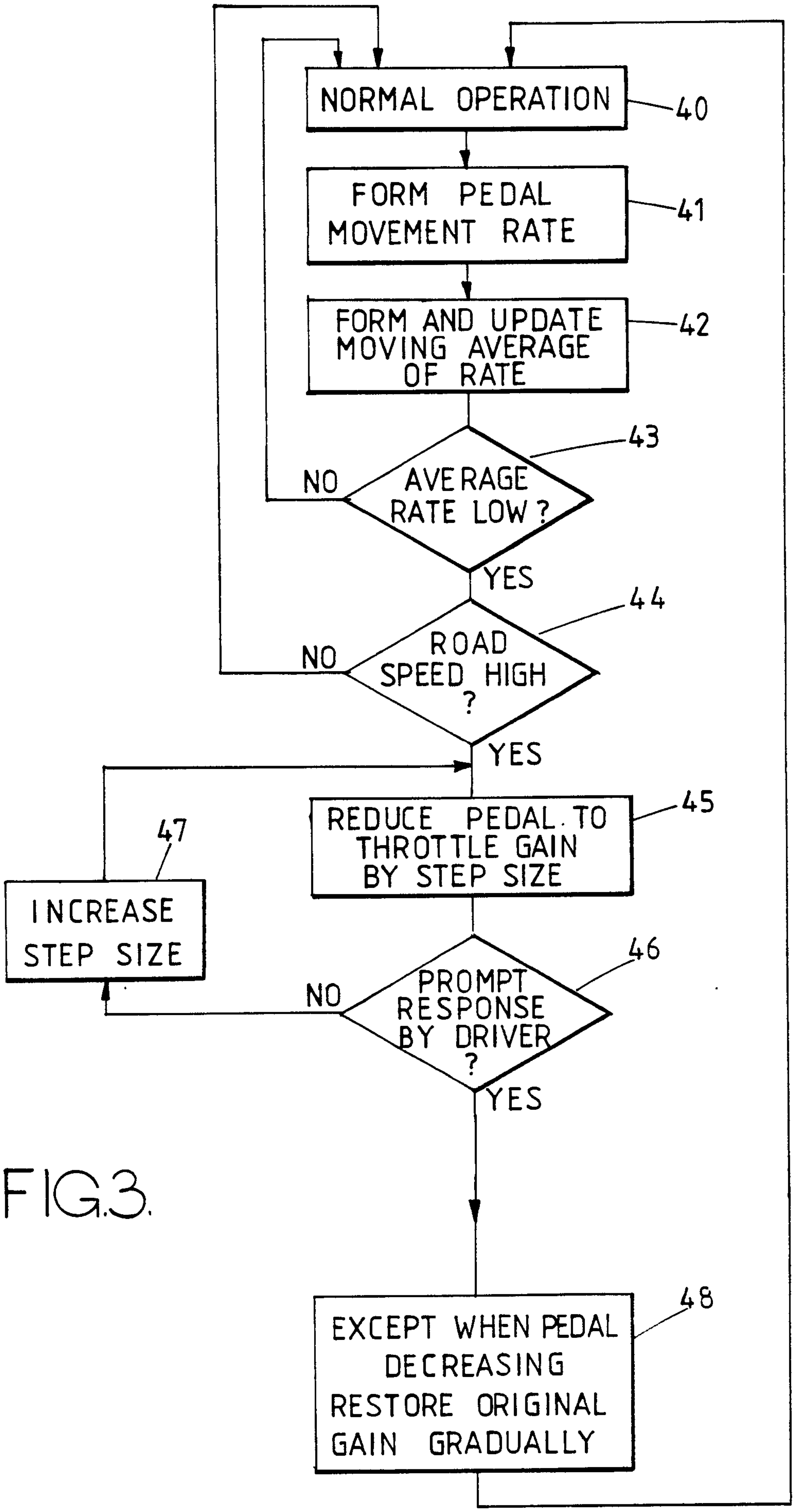

NORMAL OPERATION
40
FORM PEDAL MOVEMENT RATE
41
FORM AND UPDATE MOVING AVERAGE OF RATE
42
AVERAGE RATE LOW ?
43
NO
YES
ROAD SPEED HIGH ?
44
NO
YES
REDUCE PEDAL TO THROTTLE GAIN BY STEP SIZE
45
INCREASE STEP SIZE
47
PROMPT RESPONSE BY DRIVER ?
46
NO
YES
EXCEPT WHEN PEDAL DECREASING RESTORE ORIGINAL GAIN GRADUALLY
48

FIG.3.

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# EUROPEAN SEARCH REPORT

Application Number

EP 90 30 3950

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| X | US-A-4640243 (NISSAN MOTOR CO LTD.)<br>* figures 3-9 *<br>* column 2, lines 46 - 63 *<br>* column 3, line 30 - column 4, line 29 *<br>* column 5, line 12 - column 6, line 9 *<br>* column 7, line 12 - column 47 * | 1-3 | F02D11/10<br>F02D41/10 |
| A | | 5, 7-9 | |
| A | EP-A-247626 (HITACHI LTD.)<br>* page 2, line 51 - page 3, line 25 *<br>* page 6, line 54 - page 9, line 31 *<br>* page 12, line 41 - page 15, line 42 *<br>* figures 3-6, 11-13, 16 * | 1, 5-9 | |
| A | EP-A-250873 (HELLA KG HUECK & CO.)<br>* page 5, paragraph 2 *<br>* page 7, paragraph 2 - page 8, paragraph 2 *<br>* page 11, paragraph 2 - page 15, paragraph 2 *<br>* figures * | 1, 5, 8 | |
| A | EP-A-171641 (ROBERT BOSCH GMBH.)<br>* page 1, line 1 - page 5, paragraph 1 *<br>* figure * | 1 | TECHNICAL FIELDS SEARCHED (Int. Cl.5)<br>F02D |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 19 JUNE 1990 | LAPEYRONNIE P.J. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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